Table 2. Summary of Recent ASR and Aquifer Recharge Suitability Studies and Results

Project Name	Methodology Used to Determine Suitability	Results (Top Findings for ASR suitability)	Applicable in Texas (Y/N, Why?)	Lessons Learned (pros (+) and cons (-))	Main Geologic Aquifer Composition		Evaluations Included in Study (checked if applicable)			Weblink to Publications (if available)
					Infiltration	Deep Storage	Hydrogeo Setting	Excess Water for Storage	Proximity to Water Need	
International										
Web-based global inventory of managed aquifer recharge Applications	Synthesis of 1,200 case studies from 62 countries to improve understanding of role of managed aquifer recharge (MAR) in sustainable water management and adaptation	1. Increases awareness of MAR for sustainable groundwater management 2. Regional differences in type of MAR used, water source, and abstraction use	Yes. Web portal can be used to find comparable settings and approaches for planning and data validation purposes	+ Demonstrates that MAR is considered at many locations worldwide - Limited availability of technical documentation on many MAR studies impedes database integration	Variable	Variable	√	√	√	https://link.springer.com/content/pdf/10.1007/s40899-017-0212-6?wt_mc=alerts.TOCjournals&utm_source=toc&utm_medium=email&utm_campaign=toc_40899_4_2 https://inowas.com/tools/t17-global-mar-portal/
National										
LOTT Reclaimed Water Aquifer Recharge Project Aquifer Recharge	Used tracer testing and a groundwater monitoring to evaluate effectiveness of soil aquifer treatment on **infiltrated reclaimed water**, and to evaluate the risks of infiltrating reclaimed water into groundwater. Primary focus is on residual chemicals and nutrients.	1. Tracer test and water quality data support connectivity between the Shallow (unconfined) and Sea-Level (confined) Aquifers. 2. Water quality changes support the occurrence of soil aquifer treatment in both the vadose and saturated zones. 3. Rates of concentration decrease, downgradient of the infiltration basins, vary between chemicals.	Yes. Study pertains to the feasibility of using reclaimed water as recharge supply and the effectiveness of passive infiltration treatment.	+ Soil aquifer treatment is effective in further treating reclaimed water. - Facets requiring further study: vadose zone travel times, the effect of the vadose zone on reclaimed water quality, and the effect of dilution on reclaimed water.	Generally unconfined aquifer composed of sand and gravel glacial deposits.	N/A	√	N/A	√	https://lottcleanwater.org/wp-content/uploads/rwis_tracer2.pdf
Enhancing Drought Resilience with Conjunctive Use and Managed Aquifer Recharge in California and Arizona	Effectiveness of water recharged from the surface using managed aquifer recharge with surface ponds in existing operational managed aquifer recharge sites	1. GW depletion created substantial subsurface storage opportunities. 2. Local river water or transported surface water substituted for GW during wet years shifting to mostly GW pumpage during droughts. 3. Conjunctive use of SW and GW and MAR locally reversed declining GW trends in the Central Valley and in Arizona.	These studies are applicable to outcrop areas of Texas with suitable soils and aquifer materials for high levels of GW recharge. Examples include aquifer outcrops, like Brazos River Alluvial Aquifer.	+ **Conjunctive use of SW and GW can mitigate extreme floods and droughts**. + Inefficient surface water irrigation can recharge aquifers and is similar to managed aquifer recharge. - The soils and aquifers in Texas are not as suitable for surface based recharge as those in CA and AZ.	Coarse soils associated with alluvial deposits in CA and AZ derived from nearby mountains	N/A	√	√	√	https://iopscience.iop.org/article/10.1088/1748-9326/11/3/035013
An Aquifer Storage and Recovery System to Preserve and Rehabilitate Native Groundwater in Hastings, NE	Modeling and pilot studies	1. Confined geologic system 2. Porous and permeable beds 3. Structural geology is simple, no faulting or fracturing	Yes, system would be an analog for areas in the Ogallala where nitrate levels are of concern	+ **Storage system used to removed nitrates and uranium from well water** + Taking high nitrate water from the aquifer, treating it, then returning it down dip	N/A	In shallow glacial till deposits, using wells for injection	√	√	√	http://www.gwpc.org/sites/default/files/event-sessions/ASR%20-%20Jones.pdf

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					Infiltration	Deep Storage	Hydrogeo Setting	Excess Water for Storage	Proximity to Water Need	
Assessment of Increased Recharge due to Urbanization and Stormwater Detention Chandler, Arizona	GIS assessment of groundwater recharge from over 3,800 drywells and 1,400 acres of stormwater retention basins within City of Chandler	1. Permeable basin fill sediments useful for surface water recharge via drywells. 2. Drywells are successful in **recharging captured floodflow/stormwater over short time periods** 3. Study resulted in enhanced groundwater recharge and groundwater credits	Yes. Dry wells can be used to recharge large quantities of flood/stormwater quickly (Gulf Coast- Houston area).	+ Natural recharge rates enhanced by 10X via stormwater capture and injection via drywells + Estimated recharge rates 2,100 to 3,100 ac-ft. annually through retention basins and dry wells	Fine to coarse grained alluvium, with interbedded layers	Upper and Middle Alluvial Units (Quaternary and Holocene age) and Lower Alluvial Unit	√	√	√	https://www.researchgate.net/publication/299579764_Preliminary_Assessment_of_Increased_Natural_Recharge_Resulting_from_Urbanization_and_Stormwater_Retention_within_the_City_of_Chandler
Scottsdale Water Campus Vadose Zone Well Injection Scottsdale, AZ	The City of Scottsdale **recharges over 5,200 ac-ft. annually of advanced treated wastewater (AWT)** in 63, 180-ft deep vadose zone recharge wells. Vadose zone recharge wells are designed to by-pass 90 feet of low permeability surface sediments.	1. 400 ft. vadose zone, 18-inch diameter injection wells screened from 90 to 170 ft. bgs. 2. Drywells have been successfully used for over 20 years 3. Excess drywell capacity is needed to allow periodic shutdown to control clogging	Yes. **Vadose zone wells can be used to bypass low permeability surface sediments**	+ Vadose zone injection wells provide an intermediate cost solution between surface spreading and ASR injection - Clogging reduced Specific Injection Capacity (SIC) by up to 50% over 10 years; well performance can be increased by periodic shutdown and reducing injection rates	Fine-grained low permeability sediments from 0 to 90 ft., medium to coarse grained sediments deeper	Middle Alluvial Unit (Quaternary) with shallow bedrock	√	√	√	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.607.6821&rep=rep1&type=pdf https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/UA-WRRC-BB-1-18-Scottsdale.pdf
Riverbank Filtration to Improve Water Quality for Recharge Orange County, CA	Feasibility study and pilot project to evaluate use of **riverbed filtration to treat surface water for sediment removal prior to groundwater recharge**.	1. Riverbed filtration is an effective method for remove TSS, and reduce dissolved organic carbon (TOC) and nitrogen compounds (N) to minimize clogging of recharge basins. 2. Riverbed clogging is predicted but can be mitigated with surface flushing or treatment (i.e. ripping).	Yes. Similar riverbed filtration treatment could be used in Texas to treat surface water for sediment, TOC and N removal where alluvial sediments and shallow groundwater conditions are present.	+ Treatment using riverbed filtration was superior to conventional active treatment in improving water quality. - Achievable induced recharge rates were 30-44% of the design collection rate due to discrepancies between design and actual field conditions. - Recharge water infiltration and capture rates are dependent on surface water depths and static GW levels.	Recent Holocene alluvial sediments	N/A	√	√	√	http://www.gsanalysis.com/publications/Milczarek_20et_20al_OCWD_20ISMAR7.pdf http://www.gsanalysis.com/publications/Keller_20et_20al_20ISMAR7_10.pdf
GAC and IX Groundwater Treatment Pilot Test Plan Cape Fear Public Utility Authority Cape Fear, NC	The system is well established and has been cycle tested. Stored water is also being tested.	1. Consistent water source from the Cape Fear River 2. Well confined sandy aquifer 3. Large population served by the system	Yes, the system could be used to develop ASR in the Gulf Coast Aquifer	+ **Locate near larger/artery type mains to reduce infrastructure improvements where possible** + Need to have a good inventory of neighboring wells + Recharge rate to reduce impact to wells	N/A	Storage in Upper Peedee, fine to medium grained sand intermittent black clay	√	√	√	https://www.cfpua.org/DocumentCenter/View/11976/ASR-GAC-and-IX-Groundwater-Treatment-Pilot-Test-Plan-FINAL https://pubs.er.usgs.gov/publication/sir20145169

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Colorado Water Aquifer Storage and Recovery Denver Basin ASR, CO	The basin currently hosts six well fields with 45 individual ASR well. They have been successfully operated and tested since 1994. Multiple pilot studies large dataset for evaluation.	1. **Stacked aquifers provide opportunities for multiple ASR projects** 2. High population density with high spring runoff	Yes, large size of Texas aquifers can accommodate multiple ASR projects within the same basin.	+ Multiple projects in a single large basin have synergistic effects	N/A	Denver Basin in bedrock aquifers	√	√	√	http://wsnet2.colostate.edu/cwis31/ColoradoWater/Images/Newsletters/2017/CW_34_4.pdf
Equus Beds Recharge Project, KS	U.S. Geological Survey, in cooperation with the city of Wichita, developed and implemented a hydrobiological monitoring program as part of an **alluvial project** to characterize and quantify the effects of ASR on the Little Arkansas River and Equus Beds aquifer water quality	1. Project was developed to help the city of Wichita meet increasing current (2016) and future water demands. 2. An important source of groundwater because of its water quality and shallow depth to the water table 3. Large saturated thickness available for ASR.	Yes, have similar alluvial aquifers along major river courses, for example the Brazos River	+ Nitrates decreased in the upstream and downstream sites - Arsenic concentrations in surface water were larger after ASR	N/A	Aquifer is about 300 feet thick and consists of alluvial deposits of sand and gravel interbedded with clay/ silt	√	√	√	https://pubs.usgs.gov/sir/2016/5042/sir20165042.pdf https://www.usgs.gov/centers/kswsc/science/equus-beds-recharge-project?qt-science_center_objects=3#qt-science_center_objects
Developing a Sustainable Water Supply in the American West Rio Rancho, NM	Using Recharge Demonstration & Treatment Pilot Sites	1. Thick section of **porous sandstone** of the Santa Fe Group in a **structurally closed basin** 2. Arsenic problems handled with advanced treatment processes 3. Substantial source of water, Rio Grande	Yes, Closed basin of the Rio Grande Rift similar to the Bolsons of West Texas.	+ Rio Rancho is the first injection facility in NM, can learn ways to introduce ASR into areas not familiar with it.	N/A	Santa Fe Group Aquifer, a layer of unconsolidated deposits	√	√	√	https://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1026&context=subsust
Southern Nevada Water Authority ASR system Las Vegas, NV	**Long term and large scale (78 injection well sites) ASR**	1. Uses a combination of aquifer recharge wells, duel use wells, and production wells 2. Las Vegas claims they maintain the world's largest ASR system. 3. High demand for water in arid region	Yes, the size of the system could provide lessons for other large Texas cities like Dallas and Houston.	+ Size of system can be as many as 78 wells and larger	N/A	semi-consolidated interbedded sands and gravels	N/A	√	√	http://www.groundwatergeek.com/asr-by-state/nevada/las-vegas
Vadose Zone Recharge Wells: Ten Years Later at the City of Scottsdale's Water Campus Facility City of Scottsdale West Campus Facility, AZ	Performance testing of storage and recovery wells	1. For shallow alluvial aquifers it is more economical to use shallow vadose wells 2. High demand from City of Scottsdale 3. Arid conditions	Yes, vadose wells in alluvium could recharge deeper aquifers	+ More economical to **inject into shallow vadose well that ultimately recharges deeper sand units** + River water or recycled water can be used	N/A	A 63 vadose zone well field injects at a depth of 180 ft. down to an aquifer at 500 feet	√	√	√	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.607.6821&rep=rep1&type=pdf https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/UA-WRRC-BB-1-18-Scottsdale.pdf

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Monterey Peninsula Water Management District, CA	**Long term feasibility testing program**	1. Functioning successfully over a long period (started in 2006) 2. High demand area 3. Strong legislative support	Yes, taking river water and injecting into a sandstone aquifer is possible at numerous sites in Texas	+ ASR can work in basins that are highly faulted as long as geology is understood	N/A	Santa Margarita Sandstone consists of conglomerates and coarse sandstone	√	√	√	https://www.mpwmd.net/wp-content/uploads/2015/08/Proj_Sum_1.pdf
Estimating Aquifer Storage and Recovery (ASR) Regional and Local Suitability: A Case Study in Washington State, USA	**GIS scoring system to identify potential ASR locations and estimate storage capacity**	1. Regional data useful for assessment 2. GIS analysis and ranking scheme successful for screening large areas 3. 280 locations within 62 watersheds in Washington, determined that over 50% of locations evaluated are suitable for ASR and statewide injection potential equaled 6,400 million liters per day	Yes in terms of methodology for regional screening studies	+ Demonstrated that large areas could be effectively screened for ASR potential. - The analysis is dependent on adequate regional data and local scale testing is needed to verify the results.	N/A	Various alluvial and bedrock	√	√	N/A	https://doi.org/10.3390/hydrology5010007
Texas										
Identification of Geographic Areas in Texas Suitable for Groundwater Banking*	GIS spatial analysis used to screen select candidate county areas for in-depth evaluation. **At the county level, the spatial distributions of soil permeability attributes, surface slope, and proximity to surface water sources were used to identify hypothetical groundwater banking sites.**	1. The state-wide criteria identified 48 counties in Texas that were broadly suitable for groundwater banking. Six were evaluated in greater detail and 9 potential banking sites were identified. 2. Cumulative total infiltration for all of the sites was ~0.5 million ac-ft. for water availability periods ranging from 3 to 57 days. Almost half was associated with one site on the Brazos River in Parker County.	3. Yes	+ GIS analysis is an effective tool in identifying potential groundwater banking sites. - Local conditions that may not be represented in the GIS model may also need to be considered. - Incomplete WAM records. Available hydrographs used in the analyses had relatively short duration record of ~10 yr.	Based only on surface soil layer hydraulic properties to a depth of ~4-6 ft.	N/A	√	√	N/A	http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/IndividualReportPages/2001483388.asp
Aquifer storage and recovery and managed aquifer recharge using wells: Planning, hydrogeology, design and operation*	Comprehensive reference-overview of ASR technologies that use wells to recharge aquifers. Addresses key challenges surrounding ASR systems, such as project planning, aquifer characterization, well design, system operation, and source water quality and pretreatment.	1. ASR does not work everywhere. Many systems have not met expectations or failed. 2. **Proper planning of ASR projects increases the probability of their success and reduces project costs.** 3. Successful implementation of ASR project at a given location is dependent on a number of factors that can be subdivided into infrastructure, regulatory, and hydrogeological components.	Yes. Provides an overview of ASR technologies, gives guidance for unconfined, alluvial, and brackish aquifers, and covers storage of reclaimed water. Also provides an **example of an ASR feasibility ranking tool**.	-ASR systems can cause adverse hydrologic impacts during recovery (demonstrated in SAWS ASR) -Potential recovery efficiencies are often overestimated -Large-scale ASR requires an accommodating regulatory framework -Large-scale ASR may not be feasible in brackish aquifers	N/A	Siliciclastitic, carbonate, crystalline, and mixed-lithology aquifers.	√	√	√	https://www.slb.com/resource-library/book/aquifer-storage-and-recovery-and-managed-aquifer-recharge-using-wells

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An Assessment of Aquifer Storage and Recovery in Texas*	Conducts interviews with three Texas utilities utilizing ASR systems in Kerrville, San Antonio, and El Paso, and considers online survey responses from water providers who have previously studied or considered ASR but decided against implementation.	1. The chief concern of utilities who decided against ASR was the **ability to recover stored water and challenges in protecting that water.** 2. For ASR implementation, legal and regulatory matters were more challenging. 3. **Utilities with ASR systems found they reaped additional benefits over their initial objectives and ASR exceeded expectations**.	Yes. The report provides an overview of why ASR implementation has been slow in Texas, and outlines steps to increase ASR system utilization.	- Legal and regulatory obstacles provide the largest challenge to Texas ASR implementation.	N/A	N/A	N/A	N/A	N/A	http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/0904830940_AquiferStorage.pdf?d=1567703502249
Assessing aquifer storage and recovery feasibility in the Gulf Coastal Plains of Texas*	Develops a **method for rating ASR feasibility at regional aquifer scale** for the Gulf Coast and Carrizo-Wilcox Aquifer Systems. Complies a GIS database of feasibility factors and uses the database to produce ASR suitability maps.	1. The central and northern regions of the Gulf Coast Aquifer and the central and southern regions of the Carrizo-Wilcox Aquifer are most feasible for ASR. 2. Corpus Christi, Victoria, San Antonio, Bryan, and College Station are identified as candidates for ASR systems within the study area based on high ASR feasibility scores, potential source water availability, and susceptibility to drought (demonstrating need). 3. Most regions with high ASR feasibility are located between, not within, cities. Therefore, future ASR wells will likely require transmission lines to connect well fields to cities.	Yes. The analysis informs on feasibility of ASR within Texas' Gulf Coast and Carrizo-Wilcox aquifer systems. The study also provides an example of a regional ASR suitability rating system.	+ This study focuses on hydrogeological ASR suitability. Other factors not covered in this analysis, such as existing infrastructure, source water availability, and sociopolitical considerations are also important in determining ASR feasibility. Areas deemed suitable should be studied further. - It may not be accurate to count ASR wells towards a region's well density rating.	N/A	Gulf Coast Aquifer System and Carrizo-Wilcox Aquifer Systems	√	N/A	√	https://www.sciencedirect.com/science/article/pii/S2214581817302628
TWDB ASR Demo Project- New Braunfels Utilities Aquifer Storage and Recovery Demonstration Project*	Field program, including test hole and continuous core.	1. Data gathered on geochemistry, geology, and hydraulics can be utilized for TCEQ permit 2. **Brackish Edwards aquifer can be used as a storage zone for ASR**. Confinement above and below. 3. Collecting core and water quality samples is an essential step in evaluating ASR storage zone.	Yes, project is in Texas.	+ Brackish Edwards may be productive, in spite of reduced dissolution. + Regional dense member exists in this location in brackish zone. - CO_2 may be an issue due to low pH of the Edwards Aquifer.	N/A	Karst Limestone, Edwards Aquifer	√	√	√	https://www.twdb.texas.gov/innovativewater/asr/projects/EAA/index.asp

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TWDB ASR Demo Project- Victoria Aquifer Storage and Recovery Demonstration Project*	Retrofit existing well, perform cycle testing.	1. Retrofit well may perform as ASR well 2. Mobile arsenic clears below MCL after one cycle 3. **Gulf Coast Aquifer productive for ASR**	Yes, project in Texas	+ Existing production well may be retrofit for ASR - Existing wells may be problematic if old or in poor condition.	N/A	Unconsolidated sands and clays of the Gulf Coast Aquifer.	√	√	√	https://www.twdb.texas.gov/innovativewater/asr/projects/Victoria/index.asp
TWDB ASR Demo Project- Corpus Christi Aquifer Storage and Recovery Feasibility*	Exploratory test program including aquifer core, pump tests, and water quality. Modeled geochemistry of aquifer and source water. Groundwater model to simulate short/long term ASR operations. Identified storage zones, ASR capacity, operations, and costs.	1. Collecting core and water quality samples is an essential step in evaluating ASR storage zone. 2. Brackish Gulf Coast down to 800 ft yields 10-18 million gallons per day (MGD) supply with phasing. Volumetric recovery >61 %. ASR focus for industrial non-potable needs ASR over time freshens native brackish aquifer.	Yes. **The Gulf Coast Aquifer system** is similar to other sand and clay aquifers of Texas. Highly stratified with discontinuous layers of sand and clay alluvium.	+ Core tool adapted to get good recovery of fine sands for testing. + **Although soils were generally fine-grained, interbedded coarse-grained sediments provide preferential flow paths which increased recovery rates** - Pre-treat source water to reduce TSS, TOC, Mn, bacteria, NO3. Piloting needed to prove up best non-RO method.	N/A	Yes in sand lenses in between the clay.	√	√	√	https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1600011956_Corpus_Christi_ASR.pdf?d=3996.0699998773634
How much Water Can Be Captured from Flood Flows to Store in Depleted Aquifers for Mitigating Floods and Droughts?*	The volume of high magnitude flows (HMFs) (≥95th percentile) were quantified in Texas's 10 major rivers discharging to the Gulf of Mexico. Assess the availability of HMFs at the outlet gages considering water rights, instream flow requirements. Used three metrics, namely duration, intra-annual frequency, and inter-annual frequency, to describe the HMFs at each gage.	1. Unappropriated HMFs in Texas's 10 major rivers, totaling 30 million acre feet (MAF) in 2015–2017, are co-located with depleted major aquifers in Texas, including the **Texas Gulf Coast and Trinity aquifers** which provides space that could store ~80% (~20 MAF) of the recent HMFs. 2. Limited analysis in the San Antonio and Brazos river basins shows that capturing ~65% of HMFs may not negatively impact the instream flow requirements. 3. **About 80% of HMF volumes is contributed by events lasting for at least one week**, HMFs intensity is greater than aquifer injectivity. **More interim storage is needed to temporarily store those HMFs before slowly injecting them into the subsurface.**	Yes	+ Large volume (~30 MAF) of unappropriated HMFs in Texas's 10 major rivers discharged to the Gulf of Mexico in 2015 – 2017. - Current surface reservoirs cannot provide sufficient storage capacity for storing HMFs. Therefore, more interim storage space would be needed. - Instream flow requirements limit the potential to capture HMFs at the San Antonio and Brazos river basins. - In addition, Texas Instream Flow Program suggests capturing 5% of lower flows to maintain sediment transport, which is however infeasible with Texas water right appropriations.	N/A	N/A	N/A	√	N/A	https://iopscience.iop.org/article/10.1088/1748-9326/ab148e/meta

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El Paso Aquifer Recharge Program	Long term (30+ yr) aquifer recharge project utilizing ASR, spreading basins, and infiltration galleries resulting in over 60,000 acre-feet of reclaimed wastewater recharge.	1. Initial recharge of advanced treated wastewater effluent was via ASR wells. 2. Subsequent studies evaluated surface spreading which is current primary recharge method. 3. Expansion via discharge into basins constructed in ephemeral stream channel is planned.	Yes. Project is being conducted in West Texas and is a useful example for comparison of surface spreading infiltration with ASR wells.	+ Surface spreading far more effective than ASR injection. Lower maintenance and operations costs with surface spreading vs ASR wells - Caliche layer needs to be treated.	Moderately deep clay loam subsoils with soft caliche and/or gypsum sublayer	Quaternary and Tertiary basin-fill deposits.	√	√	√	https://www.sciencedirect.com/science/article/pii/S0301479705000216
City of Lubbock ASR Feasibility Study	This report evaluated ASR in the Ogallala, Edwards Trinity (High Plains), and Dockum Aquifers. These were investigated based on groundwater pumping, assessment of permitting, water availability and hydrogeoloic characterization. They **scored water supply based on confidence, reliability, sustainability, permit ability, quantity, quality, schedule, unit costs, project and annual cost.**	1. Based on **scoring of alternative strategies** there are three sites that are feasible for ASR, but need further investigation. 2. The ASR project could aid in seasonal peaking to meet summer demands. 3. They recommend conducting a location specific program to determine ASR feasibility.	Yes. They investigated the Ogallala, Edwards Trinity (High Plains), and Dockum Aquifers near Lubbock.	+ Existing water supply data and location data can be used to rank and evaluate sites + Test drilling location specific would provide valuable data in site selection. + An ASR simulation model could further refine water supply, demands, quality, storage volumes, and recharge and recovery rates.	N/A	Yes in the Ogallala, Edwards Trinity (High Plains), and Dockum Aquifers.	√	√	√	https://www.twdb.texas.gov/waterplanning/rwp/plans/2016/O/Region_O_2016_RWP.pdf?d=1764.870000013616
Preliminary Investigation and Feasibility Analysis: San Antonio ASR System	Evaluated **storage zone based on: potential well yield, native water quality, surface contamination potential, existing well density, average daily demand and total depth**. Other factors pertinent to site selection: water source, future permit limitations, existing well development data, and the characterization of geologic formations in Bexar County.	1. There are many potential groundwater storage zones underlying Bexar County. 2. Phase ASR System in 3 Phases: Phase 1 Test wells, Phase 2 laboratory analysis and geochemistry investigation, Phase 3 develop a prototypic ASR wells to confirm full scale compatibility	Yes. They investigated the Middle/Lower Trinity, Brackish Edwards, Wilcox and Carrizo in Bexar county.	+ There are potential groundwater storage zones in Bexar county + Attention to detail for well construction and gravel pack installation. + Match volume calculation from caliper log. - Be cautious of sand production, turbidity, and silt density index.	N/A	Yes in sand lenses in the Lower Wilcox.	√	√	√	http://www.twdb.texas.gov/innovativewater/asr/doc/SAWS_ASR_Step%201_OCR.pdf https://www.texasdesal.com/wp-content/uploads/2017/09/CrossBrad.pdf

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					Infiltration	Deep Storage	Hydrogeo Setting	Excess Water for Storage	Proximity to Water Need	
Kerrville Aquifer Storage and Recovery Investigation	Evaluated the aquifer based on: geologic logs, water demands, potential for storage, and field scale studies. This was done in multiple phases before a full-scale ASR operation system was put into place	1. The treated water is compatible with the aquifer minerals and water, therefore geochemical and biologically plugging of the aquifer is not expected. 2. **The Trinity Aquifer (Hosston-Sligo formations) was almost twice as thick as originally estimated increasing the storage potential.** 3. Suitable subsurface storage using screening in the production zone.	Yes. They investigated the Lower Trinity Aquifer, specifically the Hosston-Sligo sands	+ Drilling test wells is important as site hydrogeology can change - Open boreholes in the aquifer may be unstable, therefore screening the production zones is recommended. + Special design should be considering how water will be recovered at the surface	N/A	Yes in the Lower Trinity	√	√	√	http://www.twdb.texas.gov/innovativewater/asr/doc/UGRA_PhaseIIB_1992_Kerrville_OCR.pdf http://www.twdb.texas.gov/innovativewater/asr/doc/UGRA_PhaseIIA_1989_Kerrville_OCR.pdf http://www.twdb.texas.gov/innovativewater/asr/doc/UGRA_Phasel_1988_Kerrville_OCR.pdf
Brownsville Public Utility Board ASR Feasibility Study: Step 1 and 2	They recommend conducting three phases, which include: feasibility investigation, test drilling program, and ASR prototype facility construction and testing. Investigated 3 suitable geologic zones using field analysis, pump test, water quality sampling, and geophysical logging. The study also investigated the most feasible area to conduct ASR.	1. The Gravel Zone is the best area for ASR based on transmissivity and aquifer properties. 2. There are multiple locations where ASR would be feasible on PUB land. 3. A 10 MGD ASR facility could be built in phases to manage water supply.	Yes. They investigated the **alluvial materials of the Gulf Coast System (Beaumont and Lissie formations, Uvalde Gravel, and the Goliad Formation)**.	+ **Having multiple sites for future ASR growth is important.** + Phasing the ASR system can be helpful in developing wells and the ASR system.	N/A	Yes in the Chicot and Evangeline part of the Gulf Coast Aquifer	√	√	√	http://www.twdb.texas.gov/innovativewater/asr/doc/Brownsville_ASR_Step2_OCR.pdf http://www.twdb.texas.gov/innovativewater/asr/doc/Brownsville%20ASR%20Step%201_OCR.pdf
Laredo ASR Feasibility Study: Step 1	Investigated existing hydrogeological data of shallow and deep aquifer and water availability/demand data.	1. The **Laredo Formation has the greatest potential for ASR**. The deeper aquifers could have issues with plugging due to the fine grain sediments. 2. Mixing between the native and injected waters needs to be investigated. 3. It is important to understand the lateral continuity of sands and sandstones and the relative hydraulic connection between these layers and lower permeability silts and clay.	Yes. They investigated the Laredo Formation. The Larado Aquifer is not classified as a Major or Minor Aquifer by TWDB.	- Geochemical issues need to be evaluated carefully especially iron and aluminum. - Calcium carbonate precipitate in the well can lead to plugging problems. + A small percentage of stored water needs to be left as a buffer zone.	N/A	Semi-consolidated sands and sandstones interbedded with silts and clays.	√	√	√	http://www.twdb.texas.gov/innovativewater/asr/doc/Laredo_ASR_Step1_OCR.pdf

Project Name	Methodology Used to Determine Suitability	Results (Top Findings for ASR suitability)	Applicable in Texas (Y/N, Why?)	Lessons Learned (pros (+) and cons (-))	Main Geologic Aquifer Composition		Evaluations Included in Study (checked if applicable)			Weblink to Publications (if available)
					Infiltration	Deep Storage	Hydrogeo Setting	Excess Water for Storage	Proximity to Water Need	
TWDB 2017 State Water Plan	This report summarizes all of the Regional Plans and those that have included ASR as a strategy and it recommended a 1.8% water management strategy of the total water supply that ranges from 53,000 to 152,000 ac-ft. There are 43 strategies in Texas in Regions: E, F, G, J, K, L, and O. The average unit cost is $450 per ac-ft.	1. The ASR strategies are in many regions in the State Water Plan. 2. There is 152,000 ac-ft. predicted by 2070 that will come from ASR supplies. 3. Multiple areas in the state have feasibility for ASR.	Yes.	N/A	N/A	Yes	√	√	√	https://www.twdb.texas.gov/waterplanning/swp/2017/doc/SWP17-Water-for-Texas.pdf?d=1578931562091
City of Buda ASR Feasibility Study	This assessment investigated storage zones by characterizing the geology, hydrogeological setting, hydraulic properties, groundwater quality, and the distribution of existing wells to be considered in the subsequent feasibility analyses. They also investigated: source water, permitting and regulations, and ASR application/feasibility.	1. Geochemical modeling of a range of mixes of source and storage zone waters suggests there is little potential for significant precipitation and associated loss of well yield. 2. There is **isolation between the Edwards and lower Trinity Aquifers.** 3. Based on the findings of this study, meaningful volumes of untreated Edwards water could potentially be stored in middle and lower Trinity storage zones for recovery during drought or peak demands.	Yes. They investigated the Edwards and Trinity Aquifer near Buda, TX.	- Geochemical issues need to be evaluated carefully especially because the Edwards has pyrite deposits. - Dissolved metals should be monitored during pilot testing of ASR. + **The middle or lower trinity are both suitable for ASR.**	N/A	Yes in Middle or Lower Trinity.	√	√	√	https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/122929/ASR_TM_Final.pdf
Aquifers of Texas	Provides **summaries of all major and minor aquifers in Texas**, including their geology, hydrology, and water use. Includes a review of Texas groundwater management, TWDB modeling and monitoring programs, and statewide groundwater issues.	1. Aquifers with significant water level decline: the Trinity, particularly in the Dallas-Fort Worth and Waco areas; Carrizo-Wilcox in the Winter Garden irrigation area; and the Gulf Coast Aquifer around the Houston area. 2. Major water quality constituents of concern within Texas: TDS, arsenic, radionuclides, and nitrates. 3. Projected decrease in statewide groundwater availability (12.7 mil ac-ft/yr in 2010 to 9.9 mil ac-ft/yr in 2060).	Yes, understanding Texas aquifer characteristics and use is essential in evaluating ASR feasibility.	N/A	N/A	N/A	√	N/A	N/A	http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R380_AquifersofTexas.pdf?d=6819.2800000542775

Project Name	Methodology Used to Determine Suitability	Results (Top Findings for ASR suitability)	Applicable in Texas (Y/N, Why?)	Lessons Learned (pros (+) and cons (-))	Main Geologic Aquifer Composition		Evaluations Included in Study (checked if applicable)			Weblink to Publications (if available)
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Barton Springs Edwards Aquifer Conservation District Regional Plan for Desalination and Aquifer Storage Recovery Report 1 Desalination and ASR Feasibility Assessment	In this study they investigated the phasing and well field development using existing hydrogeological data collected with a multi-port well at the Texas Disposal System site.	1. The **Brackish Edwards could be used for ASR**. 2. The brackish groundwater could be run through a desalination plant and then stored using ASR. 3. ASR could provide water supplies to meet peak demands and enhance the reality during drought.	Yes. They investigated the Brackish Edwards in Travis County near Creedmoor.	- Boron may be an issue for plant life, so to reduce that a two stage RO system would be needed to be used for irrigation and human consumption. + Power generated from the landfill can be used for the desalination and possibly for the ASR wells.	N/A	Yes in the Brackish Edwards	√	√	√	https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1548321870.pdf

Note: * Designates Tier 1- One of the Eight (8) Reports specified by TWDB in RFQ. The bold text in the document signifies useful methodology and/or study results that may be applicable in developing methodologies to assess AR and ASR in Texas.